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SUGAR-CANE JUICE CLARIFICATION FOR SIRUP MANUFACTURE.

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TWO METHODS IN GENERAL USE.

Two methods of clarifying sugar-cane juice in the manufacture of cane sirup have been developed and are now in general use in this country. One process, following closely the method of clarification used in the manufacture of direct-consumption sugars and favored principally in the sugar-cane-producing region of southern Louisiana, where sugar also is manufactured, consists essentially in treating the juice, freshly expressed, with fumes of burning sulphur (SO_2) and milk of lime. The juice is heated and the coagulated impurities allowed to settle or removed by settling and skimming, after which the clear liquor is evaporated to sirup in open evaporators or vacuum pans or by a combination of open and vacuum evaporation.

The other and simpler process, used in all cane-sirup-producing regions outside of Louisiana and a small section of Texas, consists in heating the juice and skimming off the scums and coagulated material which rise as the juice becomes hot, forming a thick blanket on the surface. As a rule no chemicals are used in this process, though some sirup makers add a small amount of milk of lime to "make the skimmings rise better." This method requires only the smallest, crudest sort of equipment, but when careful attention is given produces an excellent sirup.

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DISADVANTAGES.

Both of these methods have disadvantages, thereby failing to give entire satisfaction to the sirup manufacturer. The principal disadvantage of the first or Louisiana method is that often the chemicals used in clarification injure the flavor of the sirup, but unless sufficient sulphur dioxid and lime are added to the juice the impurities separate slowly and incompletely. Too much lime makes the sirup very dark and too much sulphur dioxid gives it a metallic taste.

The second and simpler method of clarification is slow and wasteful, and unless very carefully executed the objectionable material is not removed completely. That sirup clarified by these methods is not entirely satisfactory is shown by the fact that it is not sold extensively in many parts of the United States outside of the region where it is made. One of the many reasons for this is that the consuming public of the Northern and Eastern States does not like the flavor of the Louisiana type of cane sirup and objects to the appearance of the sirup made in many parts of the other sirup-producing States.

NEW METHOD OF CLARIFICATION.

The method of clarifying cane juice for sirup manufacture described in this bulletin is the result of experimental work carried out with the object of finding a way to produce a clean sirup that is free from dirt and dregs, and at the same time retains its natural, mild, agreeable flavor.

OUTLINE OF PROCESS.

This process of clarification consists in heating the juice to a temperature just below the boiling point, intimately mixing with it a small amount of infusorial earth (sometimes called kieselguhr or diatomaceous earth), and pumping this mixture of juice and infusorial earth through a filter press. The resulting filtrate is clear and ready for evaporation to sirup. No further skimming or other treatment is necessary. The sirup obtained will be clean, free from dregs, and clearer than sirup clarified by either of the present methods. The color will depend upon the care taken to prevent scorching and caramelization. The flavor will be that of the natural cane juice, since the material added is an inert substance the function of which is to make possible the formation of a porous filter-press cake through which the juice can flow freely, leaving all the scums, dregs, and impurities.

INDUSTRIAL DEVELOPMENT.

Production of a better sirup in Louisiana and in the other sirup-producing States will follow as a result of the industrial develop-

ment of this process. A sirup attractive in its appearance and flavor will promote sales and consumption in ever increasing quantities in all parts of the United States.

In the large sirup factories of Louisiana this method of clarification would involve little change or addition to the present equipment. In small steam sirup mills in other parts of the country it would mean the installation of additional equipment, but this outlay of capital would be repaid by the saving in sugar liquor now thrown out or fed to hogs as "skimmings," and also by the improved and more uniform quality of the finished product.

EXPERIMENTAL PLANT.

Before outlining in detail this method of sirup making a description will be given of the experimental plant and equipment used in testing the practicability of clarifying cane juice with infusorial earth. The equipment employed consisted of two tanks fitted with steam coils, each holding slightly over 200 gallons, a duplex $4\frac{1}{2}$ by $2\frac{1}{2}$ by 4 steam pump, and an 18-inch plate and frame filter press having about 80 square feet of filtering area. The two tanks were connected by a header to the intake of the pump with valve arrangement such that the contents of each tank could be pumped separately into the press. This arrangement permitted one tank to be filled with juice and prepared for filtration while the contents of the other were being pumped through the press.

OPERATION.

One tank having been filled with juice, steam was turned into the heating coils and the juice heated to a point just below boiling. The desired amount of infusorial earth was added and mixed thoroughly with the hot juice, after which the mixture of infusorial earth and hot juice was pumped to the filter press. While this tankful of juice was being filtered the second tank was being filled, heated, and treated with infusorial earth so that it immediately followed the first one through the filter press. The process was repeated until filtration became very slow even at a pressure of 40 to 60 pounds, showing that the frames of the filter press had become full. This general procedure was followed in all the experiments.

EXPERIMENTS CONDUCTED.[1]

A more detailed description of some of the experiments follows.

[1] The juice used in these experiments was obtained from a sugar mill. The officials of the sugar company also cooperated in the conduct of the work. In most of the experiments the mixed dilute juice was used. The dilution was about 12 per cent, the extraction about 78 per cent, and the average Brix of the dilute juice 13°. In some of the experiments only the crusher juice was used, where the extraction was estimated to be about 40 per cent and the Brix of juice averaged 15°.

Experiment 1.

Type of juice: Crusher juice, about 40 per cent extraction.
Filtering material: Infusorial earth from Lompoc, Calif.
Amount of filtering material used: 11 pounds to 200 gallons of juice.
Result: 1,065 gallons of juice were filtered with a pressure not exceeding 40 pounds, forming a very hard, firm press cake.

Experiment 2.

Type of juice: Crusher juice, about 40 per cent extraction.
Filtering material: Infusorial earth from State of Washington.
Amount of filtering material used: 18 pounds to 200 gallons of juice.
Result: 1,000 gallons of juice filtered rapidly, leaving a firm, well-formed press cake. The filtered juice was bright and clear.

Experiment 3.

Type of juice: Whole mill dilute juice.
Filtering material: Infusorial earth from Lompoc, Calif.
Amount of filtering material used: 10 pounds to 200 gallons of juice.
Course of filtration:

		Time of filtration.	Pressure.
First	200 gallons	15 minutes.	10 pounds.
Second	200 gallons	15 minutes.	20 pounds.
Third	200 gallons	25 minutes.	30 pounds.
Fourth	200 gallons	40 minutes.	40 pounds.
Fifth	200 gallons	45 minutes.	50 pounds.
Sixth	200 gallons	1 hour 5 minutes.	60 pounds.
	1,200 gallons	3 hours 25 minutes.	

Result: The juice running from the press in this experiment was clear and brilliant, free from dirt, dregs, or sediment. It was necessary only to evaporate it to obtain a high-grade sirup. The press cake was very hard with the exception of the upper corners, which were a little soft.

Experiment 4.

Type of juice: Whole mill, dilute juice.
Filtering material: Infusorial earth from Lompoc, Calif.
Amount of filtering material used: 12 pounds to 200 gallons of juice.
Course of filtration:

		Time of filtration.
First	200 gallons	15 minutes.
Second	200 gallons	15 minutes.
Third	200 gallons	15 minutes.
Fourth	200 gallons	30 minutes.
Fifth	200 gallons	45 minutes.
	1,000 gallons.	2 hours.

Maximum pressure, 50 pounds.

Result: During the entire filtration the juice filtered freely and clearly, slowing up somewhat, however, as the frames became filled. The resulting press cake was very firm, each frame being completely filled.

EXPERIMENT 5.

Filtering material: From Lompoc, Calif.
Amount of filtering material used: 11 pounds to 200 gallons of juice.
Result: 1,150 gallons were filtered. The total time of filtration was between 3 and 4 hours, the pressure never rising above 50 pounds. A firm press cake was formed, completely filling the frames.

EXPERIMENT 6.

Filtering material: Infusorial earth from State of Washington.
Amount of filtering material used: 11 pounds to 200 gallons of juice.
Result: 800 gallons ran through rapidly and clearly with a pressure of not over 40 pounds. On attempting to filter more, the pressure ran up rapidly. The press cake was firm, but the frames were filled only three-fourths of the way to the top.

An outline of these experiments is given in Tables 1 and 2.

TABLE 1.—*Filtration of sugar-cane juice with infusorial earth.*

WHOLE MILL JUICE.

Experiment No.	Juice filtered.	Source of infusorial earth.	Amount used.	Maximum pressure.	Time of filtration.	Remarks.
	Gallons.		*Pounds.*	*Pounds.*		
3	1,000	Lompoc, Calif.	60	60	.....	Firm press cake formed; clear filtrate.
5	1,200	.....do.....	60	60	3 hours, 25 minutes.	Very firm press cake formed; clear filtrate.
8	1,000	.....do.....	60	50	2 hours.....	Very firm press cake; filtration rapid and smooth.
9	1,100	.....do.....	70	50	.....	Press cake slightly soft at top.
10	1,200	.....do.....	72	60	.....	Very hard press cake; filtration very slow toward the end.
12	1,000	.....do.....	60	40	.....	Filtration rapid; filtrate clear and cake firm.
15	1,100	.....do.....	60	60	3 hours, 14 minutes.	Good filtration in all respects.
21	1,100	.....do.....	64	50	4 hours, 15 minutes.	Press cake very firm; filtrate clear.
22	1,150	.....do.....	64	50	.....	Filtration satisfactory in all respects.
24	800	State of Washington.	44	High.	.....	Frames filled two-thirds with hard press cake; tops of cloths coated with slimy material.

CRUSHER JUICE.

	1,350	Lompoc, Calif.	56	40	.....	Firm press cake; clear filtrate.
	1,000	State of Washington.	92	50	.....	Very firm press cake; clear filtrate.
	1,000	Lompoc, Calif.	55	.....	.....	Satisfactory filtration in all respects.
	1,065	.....do.....	58	.....	.....	Do.
	500	Maryland.....	40	High.	.....	Unsatisfactory.

TABLE 2.—*Washing of infusorial earth press cake.*

Experiment No.	Weight of press cake.	Sucrose in press cake.	Amount of wash water.	Sucrose in washed cake.	Remarks.
	Pounds.	*Per cent.*	*Gallons.*	*Per cent.*	
3	252	6.4	.....	.....	These experiments in washing press cake followed filtration experiments of same number as described in Table 1.
8	.....	.....	200	0.0	
9	252	6.2	50	1.2	
11	.....	.....	25	4.0	
15	300	6.5	100	.8	
22	.....	.....	80	1.0	

DISCUSSION OF RESULTS.

These results show that raw cane juice, without the addition of lime, sulphur dioxid, or other chemicals, can be rapidly filtered in an ordinary plate and frame filter press when sufficient infusorial earth of a good grade is added to the heated juice. It is very desirable, however, that the infusorial earth be of very low specific gravity and also of fine mesh. The best results were obtained with commercial grades of infusorial earth obtained from California, Oregon, and Washington. It is also desirable that the infusorial earth be dry and free from lumps and trash. For successful filtration the infusorial earth must be mixed thoroughly with the juice. If it is wet and lumpy it does not mix well, and if it is trashy there is always trouble with the pump valves becoming clogged. However, with a good, clean, dry grade of infusorial earth, such as is at present on the market, no trouble whatever was experienced in obtaining a steady filtration, a firm press cake with each frame entirely filled, and a filtered liquor bright and clear.

Most of these experiments were made by adding a weighed quantity of infusorial earth to 200 gallons of juice. Based upon a 78 per cent extraction obtained by the mill, a dilution of approximately 14 per cent, and the average final Brix of the dilute juice, which was 13°, this volume of juice is almost exactly the amount obtained from 1 ton of cane. With a good quality of infusorial earth 10 pounds to the ton of cane gave a satisfactory filtration. With less than this amount the filtration was slow and there was danger of a slimy, almost impervious, coating forming on the cloths which would retard the rate of filtration.

With 10 pounds of infusorial earth per ton, 1,200 gallons of juice, or that from 6 tons of cane, could be put through the 18-inch 18-frame filter press in about three and one-half hours. Using 12 pounds of this earth to 1 ton of cane, a much more rapid filtration resulted, the juice from 5 to 5½ tons of cane filtering in two to three hours. With 11 pounds of high-grade infusorial earth per ton, satisfactory results were also obtained, the juice from 5 to 6 tons of cane filtering in about four hours. No trouble at all was experienced in obtaining a steady, clear filtration and a firm press cake. It is not well, however, to try to put through the press a larger quantity of juice than will filter readily under moderate pressure. In the press available for these experiments, using 11 pounds of infusorial earth per ton of cane, it was found best not to try to force through more than the amount of juice from 5½ tons of cane. This amount, filtered in about four hours with a pressure not exceeding 40 to 50 pounds, made a hard and firm cake throughout the entire frame. This press cake could be washed easily and thoroughly and peeled readily from the

press cloths, leaving them clean and in good condition for another filtration.

By this method of clarification a clean, clear, bright juice was obtained. Only the insoluble material in the original juice or that flocculated by heat was removed, that is, the material which the simple process of straining and skimming attempts to remove and does less thoroughly. After filtration by this method, it was necessary only to evaporate the resulting clear juice to sirup. As no further "skimmings" appeared the full heating capacity of the evaporators could be employed and evaporation was conducted as rapidly as the type of evaporator in use permitted.

The resulting sirup was not absolutely clear, owing to the separation during concentration of material which was soluble in the thin juice, but insoluble in the more concentrated sirup. However, this material formed only a slight cloud in the sirup, which is not objectionable. All the dregs and dirty-looking material which unfortunately are so characteristic of the usual run of cane sirup were removed by the filtration process, making the final sirup clean and pleasing to the eye. The color of the sirup made by this process was much better than that of the average unbleached cane sirup, as no particles of bagasse or other trash were present to stick to the coils or sides of the evaporators and cause discoloration by burning. Also the juice could be cooked to sirup more rapidly, allowing the man in charge to give his whole attention to the evaporation without having to worry about skimming or to take care lest "the skimmings boil in."

After this method of clarifying, the juice is in good condition to be evaporated under diminished pressure in one of the various types of vacuum evaporators, for it is clean and no additional scum forms as the evaporation proceeds.

ECONOMIC CONSIDERATIONS.

A description of a new method or process of manufacture would not be complete if it did not give an estimate of its practicability, convenience, cost, and advantages in comparison with the processes in general use at the present time. For purposes of comparison the prevailing methods of making sirup may be classified into three groups:

1. The method used by the individual farmer who raises only a few acres of cane and makes this cane into sirup by his own labor and that of his hired help. His equipment consists usually of a comparatively small mill, operated either by horsepower or by a gasoline engine. The juice is evaporated in a kettle, home-made vat, or baffle-plate evaporator placed directly over a wood fire. The daily production is seldom over 300 gallons and is often less than 100 gallons.

2. The method employed by the owners of small steam factories in regions outside of Louisiana. A number of these factories, scattered throughout the entire Gulf coastal region from Texas to Florida, operate by the general method which the individual farmer employs with his small equipment, but use steam power and steam-heated coils for evaporating the juice to sirup. They vary in capacity from a few hundred to several thousand gallons per day.

3. The method employed in Louisiana for making sirup. Here, too, the power is furnished by steam and evaporation is effected by steam-heated coils, but this method differs from the others in that lime and the fumes of burning sulphur are added to the juice to effect clarification, and, in addition to skimming the heated juice, settling tanks are provided in which the material is allowed to settle out. The capacities of the Louisiana sirup factories are usually much larger than those of the factories in the other States of our sirup-producing area.

Since the farmers employing the first method of sirup making operate on a very small scale and with simple equipment, it is hardly probable that the method of clarification described in this bulletin will be practicable for them. For this reason a comparison will be made between this method and the other two methods, where the sirup making is conducted on a factory or semi-factory scale.

For comparison we will consider a plant of 50 tons daily (24 hours) capacity, operating by the simple method of clarification involving skimming only. A plant of this type usually has a vat fitted with steam coils into which the juice runs direct from the mill. Here the juice is heated until the thick blanket of scum which rises begins to crack. The heat is then turned off and this blanket of scum is removed by skimming. From this clarifying vat the juice is run directly to one or more evaporators, where it is immediately cooked to sirup, additional scum being removed during the evaporation. The changes and additions to such a plant for the purpose of using infusorial earth clarification would be appreciable, namely—

(*a*) Filter presses totaling about 200 square feet in filtering area. It is estimated from experimental results obtained with the 18-inch filter press that 200 square feet of filtering area will handle the juice from 50 tons of cane in 24 hours. In actual experiment, using 11 pounds of infusorial earth to 1 ton of cane, the juice from 6 tons was handled in 4 hours. Suppose, for good measure, that 6 hours were required for handling 6 tons with 80 square feet of filtering area, then in 24 hours with 80 square feet, 24 tons could be handled, and by doubling the filtering area, or with 160 square feet, 48 tons could be handled. To make the estimate liberal an additional 40

square feet filtering area is added. Thus there appears to be no reason why the juice from 50 tons could not be filtered easily with 200 square feet filtering area in 24 hours, including all time necessary for cleaning and dressing the presses whenever necessary. In this connection it is suggested that two 100-square-feet presses would give more satisfaction than one press of 200 square feet filtering area.

(*b*) A pump with a capacity of at least 500 gallons per hour. A 6 by 4 by 6 duplex steam-piston pump would be satisfactory.

(*c*) Two or more vats of several hundred gallons capacity, each fitted with steam coils to keep the juice hot while being filtered, to serve as vats for mixing the infusorial earth with the juice, and in case no method of preheating the juice is employed, to serve also as the original juice-heating vats. While not essential, a tubular juice heater for heating the juice before it goes to the infusorial-earth-mixing tanks would be convenient, economical, and a great time saver. If a juice heater were employed the tanks mentioned above would be needed only for mixing the proper amount of infusorial earth with the juice and for keeping the juice hot while the filtration was in progress. In addition to this equipment there would, of course, be necessary a certain, though not large, amount of pipe, fittings, valves, connections, etc.

No changes would be necessary in either the grinding or the evaporating equipment, though very high extraction could be employed and a good sirup still produced by this method of clarification, whereas it is generally believed that it is impossible to make a high-grade sirup by the ordinary method of clarification when very high extraction is obtained. This method of clarification also opens up the way to the use of a less expensive method of evaporation, namely, evaporation under diminished pressure in a vacuum pan, which is impossible when skimming alone is depended upon to effect clarification.

An estimate of the cost of the above apparatus, necessary for clarification with infusorial earth, is rather difficult to give, owing to the rapid fluctuation in prices of machinery at this time. However, the cost of filter presses, pumps, and tanks as obtained from leading dealers at this time, July, 1920, is given here so that an idea at least may be obtained as to the cost of installing a filter press with its accessories.

Filter presses, 200 square feet total filtering area	$900
Pump for filter press	150
Freight, pipe, valves, etc	150
Two 400-gallon tanks, with coils	500
Total	1,700

The increased cost of operating the clarifying department of a sirup factory of 50 tons daily capacity, using infusorial earth and the above equipment, in comparison with the skimming method, may be estimated as follows:

Cost of infusorial earth delivered, 11 pounds per ton of cane, or 550 pounds, at 2 cents per pound	$11
Extra labor—one man each shift, at $2.50	5
	16[2]

The total increased cost per ton, assuming an operating period of 60 days, or a total tonnage ground of 3,000 tons, can be estimated as follows:

		Cents.
Interest on investment, at 6 per cent	$102÷3,000=	3.4
Depreciation, 10 per cent of investment	170÷3,000=	5.6
Filter cloths	80÷3,000=	2.6
Infusorial earth and extra operating expenses, as per above		32.0
Total, per ton		43.6

It is necessary now to show what financial advantages result from making sirup by this infusorial earth and filter press method to offset this apparent appreciable increase in cost. The outstanding feature is that no skimmings are obtained. Ordinarily, in a factory of this capacity, from 2,000 to 4,000 pounds of skimmings per day will be thrown away or fed to the hogs. These skimmings, with an average sugar content of 10 per cent, show a loss of 200 to 400 pounds of sugar. Figuring 8 pounds of sugar to the gallon of sirup, in grinding 50 tons of cane, from 25 to 50 gallons of sirup are lost.

In the above experiments on filtering the whole juice with infusorial earth, the resulting press cake from 6 tons of cane averaged 275 pounds weight with a sugar content of 6 per cent. From 50 tons of cane about 2,291 pounds of press cake would be obtained, which with 6 per cent sugar would give 137 pounds of sugar lost, or only 17 gallons of sirup per 50 tons. However, this loss can be reduced further. The press cake that is formed is very porous and is washed easily. Twenty gallons of water per ton of cane will easily reduce the sugar content of the press cake to 1 per cent, in which case the loss on 50 tons would be about 23 pounds of sugar, or about 3 gallons of sirup.

If a value of $1 per gallon is assumed for sirup, the saving in items of dollars and cents on 50 tons of cane can be calculated as follows:

Loss by skimming process, 25 to 50 gallons of sirup, or $25 to $50.

Loss in the infusorial earth clarification process when the cake is not washed, 17 gallons of sirup, or $17.

[2] Or 32 cents per ton.

Loss in the infusorial earth process when the cake is washed, 3 gallons of sirup, or $3.

A fair estimate is that 25 gallons of sirup would be saved on an average per 50 tons of cane. At $1 per gallon this would be a saving of 50 cents per ton. Thus the increased cost of this process is well offset by the reduction in the amount of sugar lost and in the corresponding increase in the yield of sirup.

It remains to compare this method of clarification for sirup making with that in general use in Louisiana. Here the changes required for the introduction of this process would not be so great as in the other sirup-making regions with which the comparison has been made. In Louisiana the filter press is an indispensable part of the factory equipment, being in general use throughout the sugar-and sirup-producing section of the State. As practically all of the sugar factories and many of the sirup factories are fully equipped with presses, little or no change would be necessary in altering the equipment for infusorial earth clarification. Eighty square feet of filter press area per ton-hour is sufficient for filtering the whole cane juice with infusorial earth. The cost of manufacturing sirup by this new process would be practically the same as that of the lime and sulphur process, since fuel and labor costs would be about the same. The cost of the clarifying materials would be somewhat more in the infusorial earth method, as shown below:

	Cents.
Infusorial earth, 11 pounds per ton, at 2 cents	22.0
Against—	
Lime, 2½ pounds per ton, at 1 cent	2.5
Sulphur, 1.4 pounds per ton, at 4½ cents	6.3
Total	8.8

As shown above, the cost of the clarifying materials is somewhat greater, but this is more than offset by the smaller amount of sucrose lost in the process of manufacture owing to the ease and thoroughness with which the press cake can be washed. Another advantage is that there is no need for settling tanks, skimming tanks, bag filters, or other clarifying equipment in addition to the filter presses, since the juice as it comes from the presses is ready for immediate evaporation to sirup without further treatment.

The only loss of sugar in a well-managed sirup or sugar house in Louisiana after the juice has been extracted from the cane is in the filter-press mud. Here it is figured that 36 pounds of press cake of an average sugar content of 6 per cent are produced per ton of cane, i. e., a loss of 2.16 pounds of sugar, or 0.27 gallon of sirup. Figured on a basis of $1 per gallon for sirup, this is a loss of 27 cents per ton.

In infusorial earth filtration about 45 pounds of press cake were obtained per ton. Considering the ease and rapidity with which this cake can be washed, there seems to be no reason why the sugar content should not be reduced easily to less than 1 per cent. The loss then would amount to about 0.45 pound of sugar or about 0.06 gallon of sirup per ton. On the basis of $1 sirup, this would be a loss of only 6 cents per ton. The difference in the losses, 21 cents per ton, would more than pay for the difference in the cost of the clarifying materials. However, the principal advantage would be in the improved flavor of the resulting sirup, which when properly evaporated compared favorably in color with the leading brands of Louisiana cane sirup on the market. The flavor was, in the opinion of the writer and others, milder and more agreeable, lacking the somewhat tart and metallic flavor of the usual Louisiana type of sirup.

The manufacture of sirup by the clarification method just described requires a larger outlay of capital and somewhat larger operating cost than when the manufacture is by the simple process of skimming and evaporation in open evaporators. The advantages are that a cleaner and better product can be obtained, the capacity of the evaporators can be increased—for it is not necessary to retard the evaporation as is at present the case to permit of proper skimming—the yield of sirup can be somewhat increased owing to the fact that all the scums and dregs are obtained in a hard, compact mass instead of in a thin mush containing a large amount of juice, and finally that the quality of the resulting sirup will be more uniform and will depend less upon the individual sirup maker and the care taken in skimming.

VACUUM EVAPORATION IN MAKING CANE SIRUP.

Though no exact information is available on the subject, it seems to be the general opinion that open evaporation is necessary in order to produce the finest-flavored cane sirup, some maintaining that the best flavor or aroma can be obtained only by cooking the juice in open evaporators. Some assert that sirups made in multiple-effect evaporators and vacuum pans are darker than those produced by rapid evaporation with live steam in open vats, while others state that a very high grade of sirup can be obtained, even though the evaporation is conducted mainly in vacuo, provided at some stage of evaporation it is boiled a few minutes in an open vat or brush pan. For the larger factories it is undoubtedly true that from an economic standpoint it is desirable to carry out as much of the evaporation as possible in multiple effects or vacuum pans, since evaporation can then be effected largely by exhaust steam. Even when it is necessary to use live steam the fuel consumption is not so great as in the case of open evaporation.

By employing the method of clarification with infusorial earth as described above the practicability of vacuum evaporation for sirup manufacture is increased largely. This condition is just a little different from any at present existing. In the regions where sirup is made without the use of sulphur or lime, owing to the necessity of almost continuous skimming, all factories employ open vats or pans for evaporation. In Louisiana and parts of Texas, where large amounts of sirup are made in vacuum pans, the juice is clarified with lime and sulphur dioxid. Using this infusorial earth clarification method, the juice is ready to go to the evaporators after coming from the filter presses without further treatment. The juice is clean and clear, no further scums appear during evaporation, and no coagulation or sedimentation takes place as the juice becomes more and more concentrated.

In connection with this work on clarification a small vacuum pan was installed. The filter-pressed juice was taken directly into the pan and evaporated to sirup, the pan being charged continuously until its capacity was reached. The sirup thus produced was of a light color, comparing very favorably in this respect with the highest grade of Louisiana sirups. The flavor, which, after all, is the principal quality to be considered, was excellent. It was quite mild, yet possessed the pleasant aroma and flavor characteristic of good cane sirup and was free from the peculiar after-effect that the highly sulphured sirup of Louisiana often leaves in the throat. In the author's opinion the flavor had lost nothing by the vacuum evaporation, though it may have been somewhat milder than that of the ordinary run of sirups, a characteristic that is decidedly desirable if a large market is to be developed for cane sirup in our Northern and Eastern States.

It is claimed by many that sirups made by the ordinary method of clarification with lime and sulphur are darkened by evaporation in the multiple effects and pans and that vigorous open evaporation makes a lighter sirup. This was not found to be the case with sirups clarified by infusorial earth filtration, but rather a lighter sirup was produced in the vacuum pan than in the open evaporators. No darkening of the sirup in the vacuum pan in excess of that produced by open evaporation was observed. In fact, the sirup made by vacuum evaporation was in general much lighter in color than that made entirely in open evaporators.

USE OF VEGETABLE DECOLORIZING CARBONS IN CONNECTION WITH INFUSORIAL EARTH CLARIFICATION.

Much interest is being taken at present in the use of decolorizing carbons of high efficiency in the manufacture of sirup and sugar. Those which have been produced up to the time of this writing are expensive and for economy must be used over and over again and then reclaimed when their decolorizing power begins to diminish appreciably. Therefore, it is essential for efficiency and economy that the juice or liquor which the carbon is used to decolorize should be as clean as possible, that is, with no dregs, dirt, or slime to clog up prematurely the pores of the carbon. Filtration of the juices with the aid of infusorial earth leaves them in an ideal condition for treatment by the decolorizing carbons.

Preliminary experiments with these carbons showed that a fine sirup could be produced by this method. The juice after being filtered with infusorial earth was thoroughly mixed with an amount of an active decolorizing carbon, figured as 1 per cent on the solids in the juice. After it had been repumped through a plate and frame filter press to remove the carbon, it was lighter in color and clearer than the best grades of Louisiana sirup. Though much of its characteristic so-called cane flavor was lost, that retained was very mild and pleasing and should win favor in those regions where sweetness rather than strongly marked flavors is the quality principally desired.

The end of the grinding season prevented more extensive experiments and tests on this subject.

INFUSORIAL EARTH CLARIFICATION FOR SUGAR MANUFACTURE.

A preliminary clarification of the sugar-cane juice by filtration of the whole juice with infusorial earth is a subject that should be considered by those interested in the production of white sugars on the plantations. Naturally, the cleaner the juice going to the effects and pans the better the final quality of the sugar will be.

In crushing and grinding the sugar cane a great deal of very finely divided particles of bagasse and other material becomes incorporated with the juice. By the ordinary process of sulphuring, liming, and settling much of this finer material is left in the juice as a fine suspension. This material must have some deleterious effect upon both the yield and quality of the final sugar. The precipitate formed by sulphuring and liming the juices settles rapidly and completely, so

if a juice already perfectly clean and clear could be delivered to the sulphur tower and liming tanks an exceptionally pure and brilliant juice should be obtained subsequently from the settlers. No experiments have been made on this subject, but in view of the unusually clear liquors that can be obtained by merely filtering the whole cane juice with infusorial earth it seems reasonable to suppose that such a liquor would have advantages in the manufacture of sugar as well as table sirup.

SUMMARY.

Sugar-cane juice with the addition of infusorial earth can be filtered rapidly, while hot, through a plate and frame filter press. The resulting filtered liquor will be very clean and clear.

This filtered juice can be evaporated to sirup without further treatment. No skimming is necessary, nor is it necessary to add lime and sulphur dioxid.

The juice can be evaporated either in an open evaporator or under diminished pressure in a vacuum pan. The sirup made by vacuum evaporation is lighter in color and milder in flavor than that made by evaporation in open evaporators. A very fine flavored sirup can be made by evaporating the juice previously clarified by filtration with infusorial earth in a vacuum pan to 30° Baumé and then finishing in an open pan or vat.

Infusorial earth clarification of cane juice followed by treatment with an active decolorizing carbon produces a sirup very light in color and with little characteristic flavor.

After filtering the juice with infusorial earth the resulting press cake can be rapidly and thoroughly washed free from sugar, thus insuring a minimum loss of sucrose in the factory and a proportionately larger yield of sirup.

Regardless of whether low extraction or high extraction is obtained at the mills, an excellent sirup can be made by clarifying the juice by the method described, which is feasible in any factory using steam as the source of power.

Filtration of the entire mill juice with the aid of infusorial earth before chemical treatment has possibilities of producing for the sugar industry a purer liquor, hence a better yield and better quality of sugar.

An excellent quality of sirup is made from juice clarified by filtration with infusorial earth. This sirup has a milder flavor than the present Louisiana type and is lighter in color and cleaner than the Georgia type of sirup.

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